JOURNAL

OF THE

SCIENTIFIC LABORATORIES*

DENISON UNIVERSITY

Volume 42 **Articles 11–14** **Pages 107 to 136**

EDITED BY

W. A. EVERHART

Permanent Secretary Denison Scientific Association

11. Cauchy's Inequality and Some Statistical Inequalities. By MARION WETZEL..... 107

12. A Comparative Study of the Spawning Periods of the Bluegill, Lepomis Macrochirus, the Black Crappie, Pomoxis Nigro-Maculatus (Le Seuer), and the White Crappie, Pomoxis Annularis (Rafinesque), of Buckeye Lake, Ohio. By GEORGE D. MORGAN..... 112

13. Studies in Validity: The Effect of Personality and Interest on Teachers' Marks. By ROBERT SCRIVEN CARTER..... 119

14. Reduction of Typing Errors Through Post-hypnotic Suggestion. By ROBERT SCRIVEN CARTER AND ELIZABETH ANN ORMOND..... 129

A Report Concerning THE DENISON SCIENTIFIC ASSOCIATION. By W. A. EVERHART, Secretary-Editor..... 132

GRANVILLE, OHIO

December, 1951

*Beginning with this issue the *Journal of the Scientific Laboratories* is being published independently, under the joint sponsorship of Denison University and the Denison Scientific Association, but not as a part of the Denison University Bulletin.

JOURNAL OF THE SCIENTIFIC LABORATORIES OF DENISON UNIVERSITY

The entire file of volumes 1 to 13 was destroyed by fire; no publications issued prior to 1907 are now available. Volumes 14 to date may be obtained from the editor, as separate parts, at prices as listed below, postage prepaid. Index and price lists of the earlier issues will be furnished on request.

VOLUME 20

Articles 1-3, pp. 1-36; November, 1922.....$0.50
A Review of the Biology of Sex-Determination; Sidney I. Kornhauser. 21 pp., 8 figs.
The Meander Patterns of Rios Securé and Mamoré, Eastern Bolivia; Kirtley F. Mather. 7 pp., 2 figs.
Primitive Musical Instruments of the Denison Collection; Karl H. Eschman. 10 pp., 3 plates.

Articles 4-8, pp. 37-186; June, 1923.....$0.75
Notes on Medinan, Niagaran, and Chester Fossils; Aug. F. Foerste. 84 pp., 13 plates.
The Egg and Larvae of Hesperia juba Bdv.; A. W. Lindsey. 7 pp., 1 plate.
The Occultation of Venus by the Moon on January 13, 1923; P. Biefeld. 4 pp., 1 plate.
A Botanical Survey of the Campus of Denison University; Dwight Munson Moore. 23 pp., 7 figs., 3 plates.
The Underground Migration of Oil and Gas; Kirtley F. Mather. 31 pp., 1 fig.

Articles 9-13, pp. 187-383; December, 1924.....$1.25
Trichoptilus pygmaeus Wism. and the Neuration of the Family Pterophoridae; A. W. Lindsey. 6 pp., 6 plates.
Notes on American Paleozic Cephalopods; Aug. F. Foerste. 76 pp., 22 plates.
A Report on the Theory of Relativity (Einstein Theory); Paul Biefeld. 20 pp.
Some Problems of Taxonomy; A. W. Lindsey. 18 pp., 1 plate.
Notes on the Geology of Giles County, Virginia; George D. Hubbard and Carey G. Croneis. 72 pp., 1 plate.

VOLUME 21

Articles 1-3, pp. 1-116; March, 1925.....$1.25
Notes on Cephalopod Genera; Chiefly Coiled Silurian Forms; Aug. F. Foerste. 70 pp., 23 plates.
The Cornell University Entomological Expedition South America of 1919-1920. Scientific Results No. II. Hesperiodea; A. W. Lindsey. 44 pp., 6 plates.
Photographic Record of the Partial Solar Eclipse of January 24, 1925; Paul Biefeld. 2 pp., 1 plate.

Article 4, pp. 117-283; September, 1925.....$1.50
The Agricultural Geography of the Salt Lake Oasis; Charles Langdon White. 167 pp., 34 figs.

Articles 5-7, pp. 285-404; September, 1926.....$1.25
Actinosiphonate, Trochoceroid and other Cephalopods; Aug. F. Foerste. 100 pp., 22 plates.
Brachiopods from the St. Clair Limestone, Arkansas: Norman L. Thomas. 18 pp., 1 plate.
Notes on the Preparation of Hydrogen Sulfide and Hydrogen Iodide; W. C. Ebaugh. 2 pp.

VOLUME 22

Articles 1-4, pp. 1-135, March, 1927.....$1.50
Ordovician and Silurian Cephalopods of the Hudson Bay Area; Aug. F. Foerste and T. E. Savage. 108 pp., 24 plates, 1 map.
Notes on Phylogeny in Erynnis Schr. (Thanaos Auct.); A. W. Lindsey. 7 pp., 1 fig.
The Blue Ridge of Southern Virginia and Western North Carolina; Frank J. Wright. 17 pp., 4 figs., 2 plates.
Gravels of the Blue Ridge; Frank J. Wright. 3 pp., 1 fig.

Articles 5-9, pp. 137-193, October, 1927.....$1.00
Science and Religion (Address); Robert A. Millikan. 10 pp.
Forty Years of Scientific Thought Concerning the Origin of Life (Address); Kirtley F. Mather. 11 pp.
Darwin as a Pioneer in Evolution (Address); George A. Dorsey. 14 pp.
Science and Living (Address); C. Judson Herrick. 9 pp.
Founding of the Denison Scientific Association (Address); Alfred D. Cole. 6 pp.

VOLUME 23

Articles 1-2, pp. 1-126, January, 1928.....$1.50
American Arctic and Related Cephalopods; Aug. F. Foerste. 110 pp., 29 plates.
Apatodonosaurus, A New Genus of Ichthyosaurs from the Jurassic of Wyoming; M. G. Mehl. 16 pp., 2 figs., 6 plates.

Articles 3-5, pp. 127-230, July, 1928.....$1.50
Some Brachiopods from the St. Clair Limestone, Arkansas; Norman L. Thomas. 13 pp., 1 plate.
The Phytosauria of the Wyoming Triassic; M. G. Mehl. 32 pp., 9 figs., 3 plates.
A Restudy of some of the Ordovician and Silurian Cephalopods described by Hall; Aug. F. Foerste. 58 pp., 8 plates.

Articles 6-8, pp. 231-355, December, 1928.....$1.50
Hesperioidea from the Kartabo District of British Guiana; A. W. Lindsey. 5 pp., 5 figs.
A Restudy of American Orthoconic Silurian Cephalopods; Aug. F. Foerste. 85 pp., 28 plates.
The Erosional History of the Blue Ridge; Frank J. Wright. 24 pp., 10 plates.

VOLUME 24

Articles 1-5, pp. 1-113, April, 1929.....$1.50
Hypoparia and Opisthoparia from the St. Clair Limestone, Arkansas; Norman L. Thomas. 26 pp., 1 plate.
Ordovician and Silurian of American Arctic and Subarctic Regions; Aug. F. Foerste. 54 pp., 2 plates.
Location Factors in the Iron and Steel Industry of Cleveland, Ohio; Charles Langdon White. 16 pp., 4 figs., 1 plate.
A Photographic Record of the Total Eclipse of the Moon; Paul Biefeld. 2 pp., 1 plate.
Basslerina, A New Holliniform Ostracode Genus, with Description of New Pennsylvanian Species from Texas and Oklahoma; Raymond C. Moore. 15 pp., 3 plates.

Articles 6-9, pp. 115-264, August, 1929.....$1.50
Some Proparia from the St. Clair Limestone, Arkansas; Norman L. Thomas. 14 pp., 2 plates.
Cephalopods of the Red River Formation of Southern Manitoba; Aug. F. Foerste. 107 pp., 29 plates.
A Large Fish Spine from the Pennsylvanian of North Central Texas; Raymond C. Moore. 7 pp., 1 plate.
Location Factors in the Iron and Steel Industry of the Buffalo District, New York, Charles Langdon White. 20 pp., 6 figs.

Articles 10-13, pp. 265-427, December, 1929.....$1.50
Three Studies of Cephalopods; Aug. F. Foerste. 117 pp., 23 plates.
A New Genus of Mosasaurs from Mexico, and Notes on the Pelvic Girdle of Platecarpus; M. G. Mehl. 18 pp., 5 figs., 4 plates.
Stream Piracy near Asheville, N. C.; Frank J. Wright 6 pp., 1 fig., 1 plate.
Motor Vehicle Transportation Cost and its Relation to Highway Finance; Bruce D. Greenshields. 6 pp., 1 fig.

VOLUME 25

Articles 1-3, pp. 1-164; April, 1930.....$1.50
Port Byron and Other Silurian Cephalopods; Aug. F. Foerste. 124 pp., 2 figs., 25 plates.
The Iron and Steel Industry of Youngstown, Ohio; Charles Langdon White. 22 pp., 7 figs.
New Species of Bryozoans from the Pennsylvanian of Texas; Raymond C. Moore. 17 pp., 1 plate.

Articles 4-5, pp. 165-200, August, 1930.....$1.00
Visual Localization in the Horizontal Plane; Winford L. Sharp. 9 pp.
Petroleum Products for Internal Combustion Engines; Milton Finley. 26 pp., 3 figs.

Articles 6-7, pp. 201-299, December, 1930.....$1.00
The Actinoceroids of East-Central North America; Aug. F. Foerste and Curt Teichert. 96 pp., 33 plates.
The Presence of Nybyoceras in South Manchuria; Riuji Endo. 3 pp., 1 plate.

VOLUME 26

Article 1, pp. 1-142; April, 1931.....$1.50
The Hesperioidea of North America; A. W. Lindsey, E. L. Bell and R. C. Williams, Jr. 142 pp., 33 plates.

JOURNAL

OF THE

SCIENTIFIC LABORATORIES

OF

DENISON UNIVERSITY

EDITED BY

W. A. EVERHART

VOLUME 42

1950–1951

GRANVILLE, OHIO

Published

April, 1950

April, August, December, 1951

CONTENTS OF VOLUME 42

	Page
1. Food, Agriculture and Health. By Charles Glen King	1
2. Unidentified Factors in Wheat Germ Oil Influencing Reproduction (A Preliminary Report). By Ezra Levin, Wynne Silbernagel, and Fred A. Nichols	6
3. Appendum V. History of Theta Chapter of Ohio, Phi Beta Kappa. By Willis A. Chamberlin	12
A Report Concerning the DENISON SCIENTIFIC ASSOCIATION. By W. A. Everhart, Secretary-Editor	17
4. The Life History of the Bluegill Sunfish, Lepomis Macrochirus, of Buckeye Lake, Ohio. By George D. Morgan	21
5. The Reaction of 2-Methyldihydrobenzofuran with n-Butyllithium. By James G. Traynham	60
6. In Dedication. By W. A. Everhart, Editor	64
7. The Paragenesis of Pitchblende-Bearing Veins. By Donald L. Everhart and Robert J. Wright	66
8. Paragenesis of a Uranium-Bearing Vein at Caribou, Colorado. By Harold D. Wright	75
9. Morphology of Layer Lattice Silicates. By Thomas F. Bates	83
10. Chazyan Reef Facies Relationships in the Northern Champlain Valley. By Philip Oxley	92
11. Cauchy's Inequality and Some Statistical Inequalities. By Marion Wetzel	107
12. A Comparative Study of the Spawning Periods of the Bluegill, Lepomis Macrochirus, the Black Crappie, Pomoxis Nigro-Maculatus (Le Seuer), and the White Crappie, Pomoxis Annularis (Rafinesque), of Buckeye Lake, Ohio. By George D. Morgan	112
13. Studies in Validity: The Effect of Personality and Interest on Teachers' Marks. By Robert Scriven Carter	119
14. Reduction of Typing Errors Through Post-hypnotic Suggestion. By Robert Scriven Carter and Elizabeth Ann Ormond	129
A Report Concerning the DENISON SCIENTIFIC ASSOCIATION. By W. A. Everhart, Secretary-Editor	132
15. Subject and Author Index	135

CAUCHY'S INEQUALITY AND SOME STATISTICAL INEQUALITIES[1]

MARION WETZEL[2]

1. *Introduction.* The purpose of this paper is to show the basic significance of Cauchy's inequality in connection with various correlation coefficients. Several methods have geen given to verify desirable inequalities of these coefficients. In particular we mention the treatment contained in Cramér's "Mathematical Methods of Statistics" [1, pp. 301–308]. It is our object here to consider the role of Cauchy's inequality in giving certain of these desired relations directly and in satisfying the necessary conditions in the theory of quadratic forms for the case of multiple linear regression and correlation. We also point out some related inequalities. We shall show that at each step the verification of the desired statistical inequality reduces precisely to the existence of the Cauchy inequality.

The simple linear correlation coefficient is given by $r = \dfrac{\Sigma xy}{\sqrt{\Sigma x^2 \Sigma y^2}}$, where the variables represent deviations from the means. It follows immediately by Cauchy's inequality that $-1 \leq r \leq +1$, equality holding in case the variables are proportional.

The determinant,

$$(1) \qquad R = \begin{vmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \cdots & & & \cdots \\ r_{n1} & r_{n2} & \cdots & r_{nn} \end{vmatrix}, \qquad r_{ij} = r_{ji}, \qquad r_{ii} = 1,$$

(r_{ij} representing the correlation coefficient between the variable x_i and x_j) is useful in defining the various measures in multiple linear regression theory [2, pp. 112–120]. We have

$$(2) \qquad R = \frac{1}{\Sigma x_1^2 \Sigma x_2^2 \cdots \Sigma x_n^2} \cdot \begin{vmatrix} \Sigma x_1^2 & \Sigma x_1 x_2 & \cdots & \Sigma x_1 x_n \\ \Sigma x_2 x_1 & \Sigma x_2^2 & \cdots & \Sigma x_2 x_n \\ \cdots & & & \cdots \\ \Sigma x_n x_1 & \Sigma x_n x_2 & \cdots & \Sigma x_n^2 \end{vmatrix} = \frac{1}{\Sigma x_1^2 \Sigma x_2^2 \cdots \Sigma x_n^2} C \geq 0,$$

[1] Submitted in June 1951.

[2] Associate Professor of Mathematics, Denison University.

since $C \geq 0$ by Cauchy's inequality for n variables. The equality sign holds if and only if there is linear dependence among the n variables.

2. *Multiple Correlation.* The multiple correlation coefficient is given by

$$r_{1\cdot 23\cdots n}\sqrt{1-\frac{R}{R_{11}}}.$$

Hence we should like to know that $R_{11} \geq R \geq 0$. The second inequality is given by (2); and in connection with the first inequality we have the following theorem.

THEOREM 1. The quadratic form

$$F(r_{12}, r_{13}, \cdots r_{1n}) = -\begin{vmatrix} 0 & r_{12} & \cdots & r_{1n} \\ r_{21} & 1 & \cdots & r_{2n} \\ \cdots & & & \cdots \\ r_{n1} & r_{n2} & \cdots & 1 \end{vmatrix}$$

is positive semidefinite.

PROOF. From the coefficients of the variables in F we have the sequence of determinants,

$$R_{11}, \begin{vmatrix} R_{11} & R_{12} \\ R_{21} & R_{22} \end{vmatrix}, \cdots, \begin{vmatrix} R_{11} & R_{12} & \cdots & R_{1,n-1} \\ R_{21} & R_{22} & \cdots & R_{2,n-1} \\ \cdots & & & \cdots \\ R_{n-1,1} & R_{n-1,2} & \cdots & R_{n-1,n-1} \end{vmatrix},$$

where

$$R = \begin{vmatrix} 1 & r_{23} & \cdots & r_{2n} \\ r_{32} & 1 & \cdots & r_{3n} \\ \cdots & & & \cdots \\ r_{n2} & r_{n3} & \cdots & 1 \end{vmatrix}.$$

We note that R here is R_{11} of (1). By a well known transformation upon determinants it can be shown that

$$\begin{vmatrix} R_{11} & R_{12} & \cdots & R_{1k} \\ R_{21} & R_{22} & \cdots & R_{2k} \\ \cdots & & & \cdots \\ R_{k1} & R_{k2} & \cdots & R_{kk} \end{vmatrix} = R^{k-1}R_{11,22,\cdots,kk}. \tag{3}$$

Hence our sequence of determinants reduces to

$$R^0R_{11}, \quad RR_{11,22}, \quad R^2R_{11,22,33}, \quad \cdots, \quad R^{n-3}, \quad R^{n-2}, \tag{4}$$

which by (2), or Cauchy's inequality, are all ≥ 0. A well known theorem from the theory of quadratic forms states that the quadratic form

$$F(x_1, x_2, \cdots, x_n) = \sum_{i=1}^{n}\sum_{j=1}^{n} a_{ij}x_ix_j, \qquad a_{ij} = a_{ji},$$

is positive definite if and only if the determinants $\Sigma\ (\pm)\ a_{1i}a_{2j}\cdots a_{ml}$, $m = 1, 2, \cdots, n$ are positive. Therefore if each member of the sequence in (4) is >0, we immediately have that F is positive definite. If any member is equal to zero, we have linear dependence.

Cauchy's inequality also gives us a means of comparing the multiple correlation coefficient with certain of the simple correlation coefficients. That is, we should like to know that $r_{1.23\cdots n} \geq r_{1j}$, $j = 2, 3, \cdots, n$ and in this connection we have the following theorem.

THEOREM 2. The quadratic form

$$F(r_{12}, r_{13}, \cdots, r_{1n}) = -\begin{vmatrix} r_{12}^2 & r_{12} & \cdots & r_{1n} \\ r_{21} & 1 & \cdots & r_{2n} \\ \cdots & & & \cdots \\ r_{n1} & r_{n2} & \cdots & 1 \end{vmatrix}$$

is positive semidefinite.

PROOF. Similar to Theorem 1 we have from the coefficients of the variables in F the sequence of determinants,

$$R_{11} - R, \begin{vmatrix} R_{11} - R & R_{12} \\ R_{21} & R_{22} \end{vmatrix}, \cdots, \begin{vmatrix} R_{11} - R & R_{12} & \cdots & R_{1,n-1} \\ R_{21} & R_{22} & \cdots & R_{2,n-1} \\ \cdots & & & \cdots \\ R_{n-1,1} & R_{n-1,2} & \cdots & R_{n-1,n-1} \end{vmatrix},$$

where

$$R = \begin{vmatrix} 1 & r_{23} & \cdots & r_{2n} \\ r_{32} & 1 & \cdots & r_{3n} \\ \cdots & & & \cdots \\ r_{n2} & r_{n3} & \cdots & 1 \end{vmatrix}.$$

This sequence of determinants reduces to

(5) $\qquad R_{11} - R \geq 0$

(6) $\qquad R^{k-1}\,[R_{11,22,\cdots,kk} - R_{22,33,\cdots,kk}] \geq 0, \qquad k = 2, 3, \cdots, n-2,$

$\qquad R^{n-2} - R \cdot R^{n-3} = 0.$

A well known theorem from the theory of quadratic forms states that the quadratic form

$$F(x_1, x_2, \cdots, x_n) = \sum_{i=1}^{n}\sum_{j=1}^{n} a_{ij}x_ix_j, \qquad a_{ij} = a_{ji},$$

is positive semidefinite if the determinants $\Sigma(\pm)a_{1i}a_{2j}\cdots a_{ml}$, $m = 1, 2, \cdots, n-1$ are positive and the determinant $\Sigma(\pm)a_{1i}a_{2j}\cdots a_{nl}$ equals zero. If (5) and (6) are >0 then F is positive semidefinite. And if (5) or (6) is equal to zero we have linear dependence.

Actually the multiple correlation coefficients form a non-decreasing sequence, so that the result of Theorem 2 is contained in the relation

$$r_{1.23\cdots k-1} \leq r_{1.23\cdots k}, \qquad k = 4, 5, \cdots, n, \tag{7}$$

if we first show directly that $r_{12} \leq r_{1.23}$. Equality holds in (7) if and only if $R_{1k} = 0$. Since it can be shown that $R_{11}R_{kk} - R_{1k}^2 = RR_{11,kk}$ we have $\frac{R_{kk}}{R_{11,kk}} \geq \frac{R}{R_{11}}$, $(R_{11} \neq 0)$, which gives the desired relation.

3. *Partial Correlation.* Cauchy's inequality together with some of the results from the preceding sections enable us to determine desired relations involving the various partial correlation coefficients. The partial coefficient for the first two variables is given by $r_{12.34\cdots n} = -\frac{R_{12}}{\sqrt{R_{11}R_{22}}}$. Since $R_{11}R_{22} - R_{12}^2 = RR_{11,22}$ it follows immediately from (2) that

$$-1 \leq r_{12.34\cdots n} \leq +1. \tag{8}$$

And from (2) and Theorem 1 it follows that

$$r_{12.34\cdots n} \leq r_{1.23\cdots n}. \tag{9}$$

From a function point of view we observe the relation

$$r_{1.23\cdots n}^2 = \sqrt{\frac{R_{22}}{R_{11}}}\, r_{12.34\cdots n}\, r_{12} + \sqrt{\frac{R_{33}}{R_{11}}}\, r_{13.24\cdots n}\, r_{13} + \cdots + \sqrt{\frac{R_{nn}}{R_{11}}}\, r_{1n.23\cdots n-1}\, r_{1n}. \tag{10}$$

4. *Related Forms.* Cauchy's inequality is of fundamental importance in other types of regression and correlation analysis. We shall mention only two cases here.

Given the polynomial function $y = \Sigma_{k=0}^{n} a_k x^k$ where the a_k are determined by least squares, it can be shown that the standard error of estimate is given by

$$S_e^2 = \frac{R^*}{NR_{11}^*}, \qquad \text{where } R^* = \begin{vmatrix} \Sigma y^2 & \Sigma y & \Sigma xy & \cdots & \Sigma x^n y \\ \Sigma y & N & \Sigma x & \cdots & \Sigma x^n \\ \Sigma xy & \Sigma x & \Sigma x^2 & \cdots & \Sigma x^{n+1} \\ \cdots & & & & \cdots \\ \Sigma x^n y & \Sigma x^n & \Sigma x^{n+1} & \cdots & \Sigma x^{2n} \end{vmatrix}, \tag{11}$$

It remains to show that

$$R_{11}^* 2y^2 \geq R^* \geq 0. \tag{12}$$

Noting that R^* is a special case of C from (2) and using the results of Theorem 1, we can obtain (12).

The orthogonal least squares line is given by $y = x \tan \phi$, where

$$\tan \phi = \frac{2\Sigma xy}{\Sigma x^2 - \Sigma y^2 + \sqrt{(\Sigma x^2 - \Sigma y^2)^2 + 4(\Sigma xy)^2}},$$

representing the angle between the line and the positive direction of the x-axis. If the standard error of estimate is measured in terms of orthogonal distances then it can be shown that $r^2 = \tan \phi \left(\frac{\Sigma xy}{2y^2}\right)$. And from this it can be shown that $-1 \leq r \leq +1$ since $\Sigma x^2 \Sigma y^2 - (\Sigma xy)^2 \geq 0$.

REFERENCES

1. Cramér, Harold, Mathematical Methods of Statistics, Princeton University Press, Princeton, New Jersey, 1946.
2. Hoel, Paul G., Introduction to Mathematical Statistics, John Wiley and Sons, Inc., New York, 1947.

A COMPARATIVE STUDY OF THE SPAWNING PERIODS OF THE BLUEGILL, LEPOMIS MACROCHIRUS, THE BLACK CRAPPIE, POMOXIS NIGRO-MACULATUS (LE SEUER), AND THE WHITE CRAPPIE, POMOXIS ANNULARIS (RAFINESQUE), OF BUCKEYE LAKE, OHIO[1]

GEORGE D. MORGAN[2]

INTRODUCTION

During the years 1949, 1950 and 1951 a study was made of the life histories of the bluegill sunfish, the black crappie and the white crappie of Buckeye Lake. The life history of the bluegill has already been published, Morgan (10). We are now accumulating data on the life histories of the black crappie and the white crappie. This paper is a part of this work and deals with the comparative spawning periods of these fishes.

I am indebted to Paul Chanley, senior student at Denison University, for his help in compiling these data, both in the laboratory and in the field. Also I am indebted to Messrs. E. L. Wickliff, Lee Roach, John Pelton, and Ray Riethmiller, of the Fish Management section of the Ohio Division of Natural Resources, for their suggestions and criticisms, and for the use of equipment for carrying on this work.

MATERIALS AND METHODS

For this study fish were removed from test nets at intervals of a few days from March to November. They were taken to the laboratory where studies were made of growth, food habits, embryonic development, and the extent of the spawning period.

A fairly accurate picture of the extent of the spawning period of a fish can be determined by comparing the weight of the ovaries with the body weight, as described by Morgan (10). The ratio obtained by dividing the weight of the ovaries into the body weight is then plotted on graph paper. In this way the beginning and the end of the spawning period can be easily followed. In fishes that are ready to spawn these ratios drop to below twenty and in some species to below ten. The ratio of each fish was determined, and also the average ratio for all the fish taken evey ten days was computed.

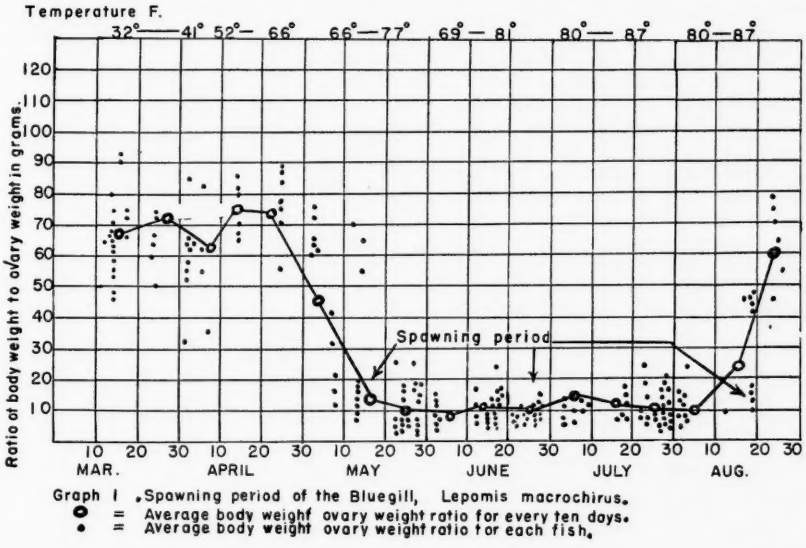
THE SPAWNING PERIOD OF THE BLUEGILL

A total of 375 male and female bluegills was removed from the test net from March through August of 1950. Beginning in March the body weight–ovary

[1] Submitted in November 1951.

[2] Associate Professor of Biology at Denison University and Fish Production Foreman of the Ohio State Division of Wild-life, Department of Natural Resources.

weight ratios vary from 48 to 90. It is interesting to note that these ratios are about the same as during the end of the spawning period in late August and September (Graph 1). During April the ratio in some bluegills drops to 36. This indicates increased ovarian activity preparatory to spawning. Between April 10 and May 10 there is a considerable building up of the ovaries in all of the fishes taken. The body weight–ovary weight ratios in some fishes drop to as as low as 16. Those with low ratios are about ready to spawn. Between May 10 and May 15 gravid females with ratios of 5 and 8 were removed from the net. The majority of the fishes taken at this time had low ratios with an average of 15. The bluegill begins to spawn in Buckeye Lake when the average ratio drops to 10 or below and at a temperature of 67°F. The ovaries at this time are quite ripe.



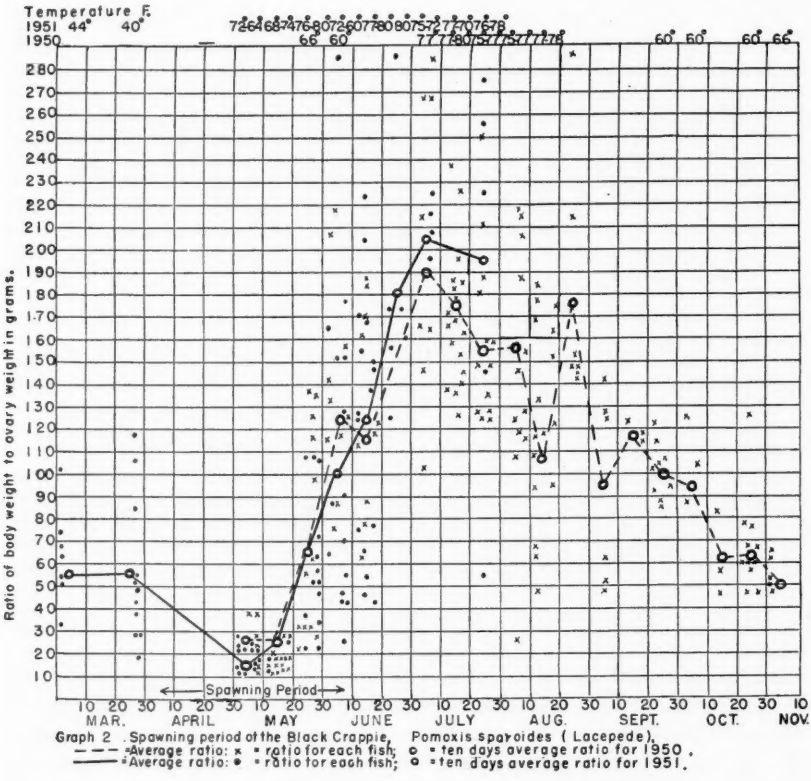
Graph 1 .Spawning period of the Bluegill, Lepomis macrochirus.
O = Average body weight ovary weight ratio for every ten days.
• = Average body weight ovary weight ratio for each fish.

Mature eggs can be removed easily at this time with very little pressure on the sides of the abdomen. Spawning continues at intervals during the summer to about the middle of August (Graph 1) when the temperature range is between 80° and 87°F. A few gravid females were taken as late as August 20 and at a temperature of 87°F. However, most of the bluegills are through spawning by August 10. By August 25 the body weight–ovary weight ratio is between 34 and 78 and it continues to climb during September. It appears that in the bluegills the ovaries are held over in this condition through the winter until April when the building up process begins. The ratio in the bluegill seldom goes above 90.

THE SPAWNING PERIOD OF THE BLACK CRAPPIE

Black crappies were removed from the net from March 1 to November 2, 1950 and 1951. Body weight–ovary weight ratios were determined as described for the bluegill. A total of 238 females and 261 males was included in this study.

The body weight–ovary weight ratios of black crappies taken on March 1 ranged from 31 to 102 as compared with bluegill ratios of 48 to 90 during the same period. On March 28 a ripe female black crappie was taken with a body weight–ovary weight ratio of 18. The temperature of the lake at this time was 40°F. The ratio for the day varied from 18 to 116 (Graphs 2 and 4). Due to unfavorable weather no fishes were taken during April. On May 1, when netting activities were resumed, the average body weight–ovary weight ratio was 16.

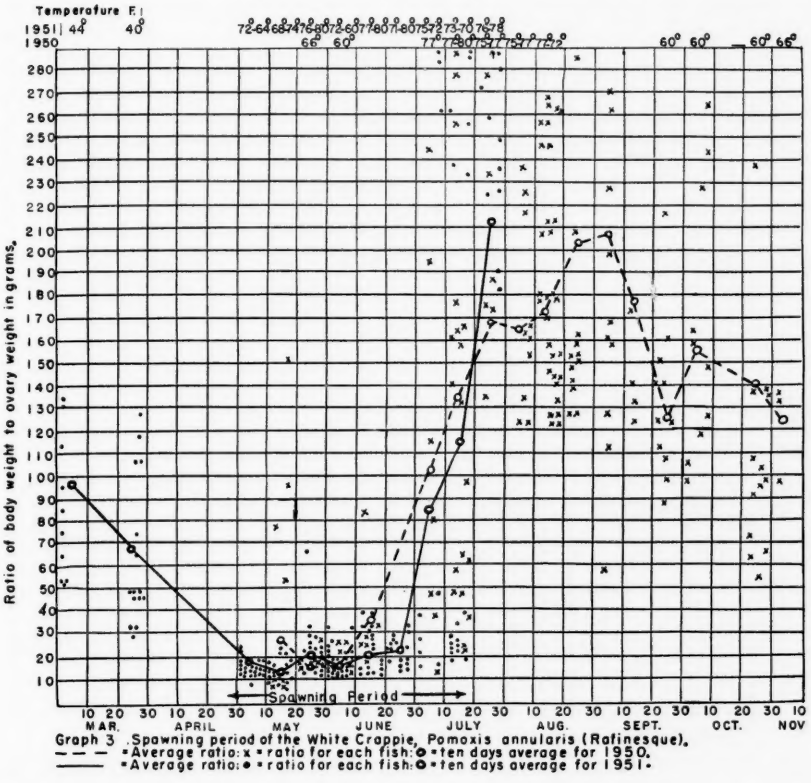

Temperature F.
1951 44° 40°
1950
Ratio of body weight to ovary weight in grams.
Spawning Period
MAR. APRIL MAY JUNE JULY AUG. SEPT. OCT. NOV.

Graph 2. Spawning period of the Black Crappie, Pomoxis sparoides (Lacepede).
– – – = Average ratio: x = ratio for each fish; o = ten days average ratio for 1950.
——— = Average ratio: • = ratio for each fish; o = ten days average ratio for 1951.

Most of the fishes taken at this time were ripe males and females. Between May 10 and May 20 the ratio began to climb. The average ratio during these 10 days was 25. From May 20 to May 30 the average continued to climb. Some females taken at this time had a ratio of 21. Several of these specimens were partially spent while others were still in the process of ripening. Spent, partially spent, and ovaries that have not yet ovulated are recognized easily by their flaccidity and also by their color. Spent and partially spent ovaries are deep brown to orange in color, while those that are ripening, and those that are ripe are light straw colored. On June 1 one ripe female was taken with a ratio of 16. The

water temperature was 60°F. The majority of the black crappies taken at this time were either spent or were partially spent. The average ratio of all fishes taken at this time was 100. This marks the end of the spawning period of the black crappies in Buckeye Lake.

According to A. S. Pearse (13) the earliest spawning period of the black crappie at Lake Wingra, Wisconsin, was May 20, and at a temperature of 68°F. Spawning in Lake Wingra continued until July 15 and at a temperature of

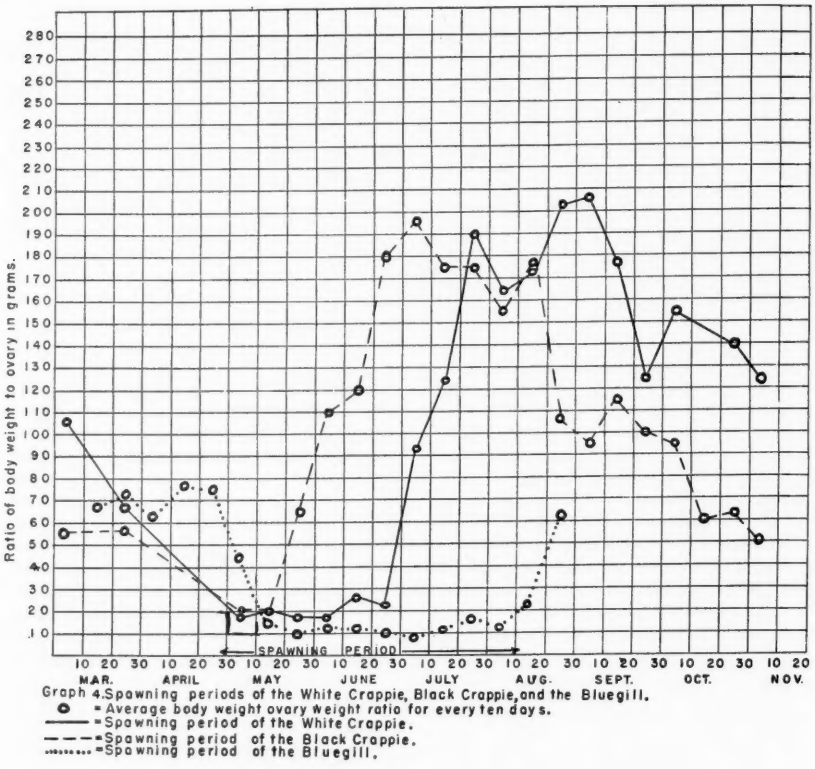


Graph 3 .Spawning period of the White Crappie, Pomoxis annularis (Rafinesque).
– – – = Average ratio: x = ratio for each fish: O = ten days average for 1950.
——— = Average ratio: • = ratio for each fish: O = ten days average for 1951.

87°F. Richardson (13) observed black crappies spawning in a pond near Havana, Ill., on May 11, 1911, after the water temperature had reached about 67°F. In Buckeye Lake ripe females were taken on March 29 when the temperature was 40°F. No ripe females were taken after June 1; and the water temperature at this time was 60°F.

The ratio during June continued to climb until by July 10 the average ratio was above 200 (Graphs 2 and 4). It is interesting to note that during July of both 1950 and 1951 the ratio was practically the same. This appears to be the highest ratio for the black crappie. Then the ratio begins to drop. By August it

has dropped to an average of 78. By the end of October the average bodyweight–ovary weight ratio has dropped to 50. No record was obtained during December, January, and February. Test net operations were again resumed on March 1. It is interesting to note that the average body weight–ovary weight ratio of the black crappies taken at this time was about the same as it was in November. Hence it appears that in these fishes the ovaries develop during late summer and early winter and are carried through the winter in this condition. In March



Graph 4. Spawning periods of the White Crappie, Black Crappie, and the Bluegill.
o = Average body weight ovary weight ratio for every ten days.
——— = Spawning period of the White Crappie.
– – – = Spawning period of the Black Crappie.
..... = Spawning period of the Bluegill.

the ovaries are almost ready to ovulate. In contrast, the building up of the ovaries of the bluegill does not take place in the fall but occurs suddenly during April and May.

THE SPAWNING PERIOD OF THE WHITE CRAPPIE

White crappies were removed from the net, and the body weight–ovary weight ratios were determined as described for the bluegill and the black crappie. A total of 462 males and females of all sizes was examined during 1950 and 1951, from March 1 to November 2.

The body weight–ovary weight of the white crappies removed from the net on March 1 ranged from 50 to 132 with an average of 98 for all the fishes taken (Graphs 3 and 4). The water temperature at this time was 40°F. On March 28 the ratios dropped to between 28 and 126 with an average ratio of 68. Those with a ratio of 28 were almost ripe and ready to spawn. No white crappies were taken during April. On May 2, when netting was again resumed, the body weight–ovary weight of the white crappies taken had dropped to between 12 and 22 and most of the fishes were ripe males and females. This low ratio is an indication of active spawning. These low ratios continued through May, June and into July. Gravid females were removed from the net as late as July 20, and at a temperature of 80°F. (Graph 3).

From these observations it appears that the white crappie begins to spawn in late March or early April and continues through the summer to July 20.

SUMMARY AND CONCLUSIONS

1. Bluegills in Buckeye Lake begin to spawn in early May and continue to spawn at intervals throughout the summer until the middle of August. The water temperature during this period in 1949 varied from 67°F. to 87°F.

2. In the bluegill the building up of the gonads in preparation for spawning takes place quickly in the spring between April 20 and May 15. The body weight–ovary weight ratio drops at this time from 90 to below 16.

3. The body weight–ovary weight ratio is lower in bluegills than in the crappies.

4. The black crappie begins to spawn during the last of March and the beginning of April, and ends between June 1 and 5.

5. The water temperature during the spawning period of the black crappie in 1951 varies from 40°F. in March to 60°F. in June.

6. The building up of the ovaries in the black crappie takes place during the fall, and the fish is ready to spawn early in the year with little further development.

7. The spawning period of the white crappie begins at the end of March and continues through the summer until July 20. The water temperature varies between 40°F. in March to 80°F. in July.

8. The extent of the spawning period of the white crappie is very similar to the spawning period of the bluegill although it begins and ends about a month earlier.

9. The building up of the gonads in the white crappie takes place in the fall as in the black crappie. Hence they are ready to spawn early with little further development.

BIBLIOGRAPHY

1. Battle, Helen I. 1940 The Embryology and Larval Development of the Goldfish (Carassius auratus L.) from Lake Erie. *Ohio Journal of Science*, No. 2, *Vol.* XL, March.

2. Barney, R. L. and Anson, B. J. 1922 The Life History and Ecology of the Orange Spotted Sunfish (Lepomis humilus). *Rep. U. S. Com. Fish*, Washington for 1922 and 1923, Appendix XV, 16 pp., 7 Figs.

3. CARBINE, W. F. 1940 Observations of the Spawning Habits of Centrachid Fishes in Deep Lake, Oakland County, Mich. *Fourth American Wildlife Conference 1939*, Washington, pp. 275–287.
4. CUNNINGHAM, J. T. 1892 Growth of Fishes and Age and Size at Which They Begin to Breed. *Mar. Biol. Assoc.* (2) *11:* 222–264 and 344–362.
5. FISH, M. P. 1932 Contributions of Early Life Histories of 62 Species of Fishes from Lake Erie and its Tributary Waters. *Bull. U. S. Bur. Fish, 47* (10): 293–348, 8 figs.
6. HICKLING, C. F. AND RUTENBERY, W. 1936 The Ovary as an Indicator of the Spawning Period in Fishes. *Jour. of Mar. Biol. 15* (1): 32–47, 8 figs.
7. JOHNSON, WENDELL L. 1945 Age and Growth of the Black and White Crappies of Greenwood Lake, Indiana. *Invest. of Indiana Lakes and Streams. 2* (15): pp. 297–324.
8. LAKE, CHARLES T. 1936 The Life History of the Fantailed Darter, *Catonotis flabellaris* (Rafinesque). *Am. Midl. Nat. 17* (3): pp. 817–830.
9. LANGLOIS, T. H. 1936 Farm Fish-Pond Culture. *Bull. 108. Dept. of Agri.* Ohio State Div. of Natural Resources.
10. MORGAN, G. D. 1951 The Life History of the Bluegill Sunfish, Lepomis macrochirus, of Buckeye Lake. Denison University Bull., *Jour. of the Sci. Labs. 42*, no. 4, April.
11. PEARSE, A. S. 1918 Habits of the Black Crappie in Inland Lakes of Wisconsin. *Rep. U. S. Comm. Fish.* (1920), 16 pp.
12. REICHARD, JACOB 1902 The Breeding Habits of Certain Fishes. *Science, N. S., Vol.* XV, no. 380, April, pp. 574–575, New York.
13. RICHARDSON, R. E. 1913 Observations on the Breeding Habits of Fishes at Havana, Ill. 1910 and 1911. *Bull. Ill. State Lab. of Nat. Hist., 19:* pp. 405–416.
14. WICKLIFF, E. L. 1933 The Practical Value of Determining the Fertility of Whitefish Eggs. *Trans. of Amer. Fish Soc. Vol.* 63, Investment Bldg., Washington, D. C.

STUDIES IN VALIDITY: THE EFFECT OF PERSONALITY AND INTEREST ON TEACHERS' MARKS[1]

ROBERT SCRIVEN CARTER[2]

INTRODUCTION

The primary significance of this problem is found in the almost universal use of marks in the public school systems of the United States. By the use of one device or another, teachers do express their judgments of the level of achievement exhibited by the various members of their classes. The marks assigned by teachers will, in many instances, influence the future school careers of pupils who receive those marks. In other cases, teachers' marks are used in connection with the grouping schedules. Children are often accelerated or retarded in grade progress on the basis of teachers' marks. Various honors, presented at graduation time, are based largely on teachers' ratings. Teachers' marks are used as one of the criteria to determine who shall be admitted to study at the college level. In other words, marks may affect a child's future academic training as well as his choice of occupation. There is, therefore, a definite need for a lucid and objective evaluation of teachers' marks in terms of validity.

Previous investigations (1) have shown that significant differences exist between the marks assigned by men and women. These differences exist regardless of the sex of the student. Although no significant differences could be found in intelligence or in algebra achievement, statistically significant differences existed in the marks assigned by teachers, differences clearly not attributable to chance. The differences, generally, gave the advantage to the girls. It was made clear that the girls were no smarter, did not know any more algebra, but they did receive higher marks.

There were definite indications that intelligence was a factor in the assignment of marks. When intelligence was partialled out, and thus held constant, the relationship between teachers' marks and achievement declined. This indicated that the teachers' marks not only reflected achievement but also intelligence. Since the relationship was far from perfect, some other factors entered into the assignment of marks by teachers of beginning algebra.

THE PROBLEM

The investigation was designed to determine whether marks assigned by teachers of beginning algebra were influenced by factors of student interest and personality. The study also sought to establish the relative significance of these factors when the sex of the student was the same as the sex of the teacher.

[1] Submitted in October 1951.

[2] Associate Professor of Psychology, Denison University.

REVIEW OF THE LITERATURE

Rinsland (4) pointed out that teachers differ on grades to be assigned because they do not agree on what to count; neither can they agree on the number of points or weights to be assigned to the things they do count. He also pointed out that teachers have different standards of severity and leniency, and that even the same teacher has different standards on different occasions. These differences can be accounted for by factors of fatigue, personality, effort, and industry, either on the part of the student or the teacher. He also stated that when all studies have been examined, it must be admitted that both the grading of an individual paper and the whole grading system are subjective, unreliable, and unfair.

Lentz (2) concluded that teachers favor girls in awarding school marks, that standardized tests place boys at a handicap, and, that teachers give credit for "hand shaking" when assigning marks.

Morton (3), in investigating the influence of pupil conduct on teachers' marks in grades five through eight, concluded that deportment is related to school marks, but that school marks are not related to intelligence, problem solving, or to reading. His study suggests that over age, *per se*, was considered in the assignment of marks. He also found little doubt that teachers "doctor" grades.

MATERIALS AND SUBJECTS

Results of an investigation of this type are of most value when they can be used for evaluation and interpretation over a wide area, or by a large number of individuals. With this in mind, the investigation was undertaken in a city in western Pennsylvania. Two hundred and sixty pupils took part in the testing program from which the basic data for this study were obtained. This investigation is based on 235 pupils taking high school algebra for the first time. In all, nine classes were used, four classes being taught by women and five classes being taught by men. Of these, 135 were boys, and 100 were girls. Since students are assigned to classes alphabetically, no known selective factors operate which would give a biased sample.

In the school in which the investigation was made, there are six teachers, three men and three women, teaching beginning algebra. The six teachers all hold valid Permanent High School Certificates issued by the Pennsylvania Department of Public Instruction. The training of the three men and three women used in this study was almost identical. Whatever effect factors of age, training, and experience may have on assigned marks was minimized.

During the last week of the first semester, the investigator administered the Intermediate Form of the California Test of Personality and the Garretson-Symonds Interest Questionnaire to all students enrolled in the course in beginning algebra in the public school of a western Pennsylvania city. One week following the end of the first semester the examiner inspected the permanent record cards for the subjects used in the investigation. These cards were in-

spected in the office of the principal. From the cards, the examiner secured the necessary information concerning the marks assigned by individual teachers to each student as an indication of his level of achievement for the semester.

RESULTS OF THE TESTING PROGRAM

For the purpose of this investigation, the sample is divided into four groups:

1. Boys taught by men teachers
2. Girls taught by men teachers
3. Boys taught by women teachers
4. Girls taught by women teachers

In the presentation of the data which follows, the results of the testing program are presented so as to reflect these categories.

A. Personality Test Results

The differences in mean scores for the various groups, together with the critical ratios, on the California Test of Personality are presented in Table I. An inspection of the table reveals that the mean score for girls is 7.30 points more than the mean score for boys. This difference represents a critical ratio of 2.89, which is statistically significant. The difference in mean score between the boys and girls taught by women, 10.58, is also significant (Critical Ratio, 2.86). Since the criterion for significance has been set at the one per cent level of confidence, the other comparisons shown in the table are not large enough to be called statistically significant. Differences as large as 7.36 between the mean score for girls taught by men and by women can be expected about nineteen times out of a thousand purely by chance. In the case of the difference in means between the boys and girls taught by men, 5.00, and in the case of the mean score for all students taught by men and by women, where the difference was 3.95, differences this large can be expected seven times in a hundred by chance (Critical Ratios, 1.51 and 1.52, respectively).

B. Interest Questionnaire Results

The Garretson-Symonds Interest Questionnaire is designed to supply a valid and reliable measure of the inclination of pupils toward the academic, commercial, or technical curricula, through a sampling of their preferences over a wide range of items (234). Since the authors of this test consider algebra to be in the academic curriculum, this investigation was concerned with only the academic score on the Garretson-Symonds Interest Questionnaire.

Comparisons between groups on the Garretson-Symonds Interest Questionnaire are given in Table II. The results on the questionnaire indicate that the mean difference of 1.71 between the boys taught by men and by women (Critical Ratio, 0.66) and the difference in mean score between girls taught by men and by women, 1.28 (Critical Ratio, 0.55), are not significant differences. Differences this large could be expected four or five out of ten times. On the other hand, differences as large as the difference in mean score between boys and girls,

15.10, (Critical Ratio, 8.78), would be expected only once in a million times. The same conclusion can be drawn with respect to the difference between the mean score for boys and girls taught by men, 14.88, and between the difference in means for boys and girls taught by women, 15.31. The critical ratios of 6.83 and 5.59, respectively, can be expected by chance only once in a million times.

TABLE I

Differences and Critical Ratios between Scores Made by Boys and Girls on the California Test of Personality

N	SEX	MEAN	SD	SE_M	$_{DIFF}(M_1 - M_2)$	SD_M	CR_M
	Taught by men						
75	Boys	138.24	19.49	2.25			
58	Girls	143.24	18.84	2.47			
					−5.00	3.31	−1.51
	Taught by women						
60	Boys	140.02	20.86	2.69			
42	Girls	150.60	16.79	2.59			
					−10.58	3.70	−2.86
	Boys (taught by)						
75	Men	138.24	19.49	2.25			
60	Women	140.02	20.86	2.69			
					−1.78	3.50	−0.51
	Girls (taught by)						
58	Men	143.24	18.84	2.47			
42	Women	150.60	16.79	2.59			
					−7.36	3.56	−2.07
	Totals (taught by)						
133	Men	140.42	19.37	1.68			
102	Women	144.37	19.97	1.98			
					−3.95	2.60	−1.52
	Totals						
135	All boys	139.03	20.13	1.73			
100	All girls	146.33	18.36	1.84			
					−7.30	2.53	−2.89

C. Relationship between Teachers' Marks and Personality

Since personality scores and teachers' marks have the highest zero order correlation, excepting intelligence and teachers' marks, it was imperative that the personality factor be controlled statistically to determine the relationship existing between teachers' marks and algebra achievement scores with personality held constant. In Table III are presented the coefficients of correlation for the zero order r's between teachers' marks and algebra achievement scores and the partial r's between these variables with personality scores held constant.

A comparison of Table III with evidence presented elsewhere (1) indicates that the magnitude of the r's does not change as greatly as in the case where intelligence is held constant. In no case does the magnitude of the partial r increase over the zero order r, which indicates that personality, of and for itself, is not so important a factor as achievement in the assignment of marks by teachers of beginning algebra.

TABLE II

Differences and Critical Ratios between Scores Made by Boys and Girls on the Garretson-Symonds Interest Questionnaire

N	SEX	MEAN	SD	SE_M	DIFF. $(M_1 - M_2)$	SD_M	CR_M
	Taught by men						
75	Boys	43.33	13.29	1.53			
58	Girls	58.21	11.88	1.56			
					−14.88	2.18	−6.83
	Taught by women						
60	Boys	41.62	16.40	2.12			
42	Girls	56.93	11.19	1.73			
					−15.31	2.74	−5.59
	Boys (taught by)						
75	Men	43.33	13.29	1.53			
60	Women	41.62	16.40	2.12			
					1.71	2.61	0.66
	Girls (taught by)						
58	Men	58.21	11.88	1.56			
42	Women	56.93	11.19	1.73			
					1.28	2.33	0.55
	Totals (taught by)						
133	Men	49.82	14.69	1.27			
102	Women	47.92	16.31	1.61			
					1.90	2.05	0.93
	Totals						
135	All boys	42.57	14.78	1.27			
100	All girls	57.67	11.60	1.16			
					−15.10	1.72	−8.78

In all cases the magnitude of the r either remains constant or decreases when personality is partialled out. When personality scores are held constant, the difference between the zero order r and the partial r is greater in the case of girls than in the case of boys. The differences are greater in the case of women teachers than in the case of men teachers. When the teacher is a woman and the student a girl, the zero order r for the variables under consideration is .35; with the same condition, the partial r is .29. This represents the largest change,

TABLE III

Coefficients of Correlation between Teachers' Marks and Algebra Achievement and between Teachers' Marks and Alegbra Achievement with Personality Held Constant

0. Teachers' Marks
1. Algebra Achievement Scores
3. Personality Test Scores

	BOYS	GIRLS	TOTAL
Taught by men			
Number	75	58	133
$r_{01.3}$	.78 ± .05	.56 ± .09	.68 ± .05
$r_{01.}$	.78 ± .05	.57 ± .09	.68 ± .05
Taught by women			
Number	60	42	102
$r_{01.3}$	.34 ± .11	.29 ± .14	.38 ± .08
$r_{01.}$	.37 ± .11	.35 ± .14	.43 ± .08
Totals			
Number	135	100	235
$r_{01.3}$	.58 ± .06	.42 ± .08	.50 ± .05
$r_{01.}$	.59 ± .06	.45 ± .08	.52 ± .05

TABLE IV

Coefficients of Correlation between Teachers' Marks and Personality, between Teachers' Marks and Personality with Intelligence Held Constant, and between Teachers' Marks and Personality with Intelligence and Algebra Achievement Held Constant

0. Teachers' Marks
1. Algebra Achievement Scores
2. Intelligence Test Scores
3. Personality Test Scores

	BOYS	GIRLS	TOTAL
Taught by men			
Number	75	58	133
$r_{03.12}$	.15 ± .11	.27 ± .12	.24 ± .08
$r_{03.2}$	.16 ± .11	.24 ± .12	.20 ± .08
$r_{03.}$	.16 ± .11	.34 ± .12	.25 ± .08
Taught by women			
Number	60	42	102
$r_{03.12}$	.29 ± .12	.21 ± .15	.30 ± .09
$r_{03.2}$	.31 ± .12	.23 ± .15	.34 ± .09
$r_{03.}$	.35 ± .11	.31 ± .14	.38 ± .08
Totals			
Number	135	100	235
$r_{03.12}$	.22 ± .08	.29 ± .09	.28 ± .06
$r_{03.2}$	.24 ± .08	.30 ± .09	.28 ± .06
$r_{03.}$	.25 ± .08	.37 ± .09	.32 ± .06

the other changes ranging in magnitude from zero, in the case of boys taught by men and all students taught by men, to five hundredths in the case of all students taught by women.

In Table IV are presented the coefficients of correlation between teachers' marks and scores on the California Test of Personality with intelligence and algebra achievement partialled out. These second order partial r's are compared with the first order partial r's as well as with the zero order r's. In every instance the personality of the student as shown by his test score, tends to influence the teacher in assigning marks as indicated by the positive coefficients. The magnitude of the coefficients indicates that the personality scores of girls

TABLE V

Coefficients of Correlation between Teachers' Marks and Algebra Achievement and between Teachers' Marks and Algebra Achievement with Interest Held Constant

0. Teachers' Marks
1. Algebra Achievement Scores
4. Interest Scores

	BOYS	GIRLS	TOTAL
Taught by men			
Number	75	58	133
$r_{01.4}$	.76 ± .05	.57 ± .09	.69 ± .05
$r_{01.}$	.78 ± .05	.57 ± .09	.69 ± .05
Taught by women			
Number	60	42	102
$r_{01.4}$	.38 ± .11	.30 ± .14	.40 ± .08
$r_{01.}$	.37 ± .11	.35 ± .14	.43 ± .08
Totals			
Number	135	100	235
$r_{01.4}$	.58 ± .06	.45 ± .08	.50 ± .05
$r_{01.}$	.59 ± .06	.45 ± .06	.50 ± .05

are a more significant factor in influencing the teachers' marks than are the boys' scores. There is also some indication that the women teachers are influenced more by the personality of students than are the men teachers.

D. Relationship between Teachers' Marks and Interest

The results of partialling out interest and showing the relationship between teachers' marks and achievement scores are shown in Table V. In view of the fact that the magnitude of the zero order coefficients of correlation changes none at all or an infinitesimal amount, it can be seen that interest has very little influence on the assignment of marks by teachers of beginning algebra.

The results of the correlations between teachers' marks and interest with achievement and intelligence partialled out are found in Table VI. Interest in academic work is a much more important factor in the determination of marks

assigned by men than marks assigned by women. In the case of boys it is much more important than in the case of girls. When women teachers are involved, the interest factor affects the boys' marks inversely, but in the case of girls, interest affects the marks directly. The factor of interest, since the magnitude of the coefficient is low, does not seem to play an important part in the assignment of marks by teachers of beginning algebra.

TABLE VI

Coefficients of Correlation between Teachers' Marks and Interest, between Teachers' Marks and Interest with Intelligence Held Constant, and between Teachers' Marks and Interest with Intelligence and Algebra Achievement Held Constant

0. Teachers' Marks
1. Algebra Achievement Scores
2. Intelligence Test Scores
4. Interest Questionnaire Scores

	BOYS	GIRLS	TOTAL
Taught by men			
Number	75	58	133
$r_{04.12}$	.28 ± .11	.12 ± .13	.36 ± .08
$r_{04.2}$	.38 ± .10	.10 ± .13	.32 ± .08
$r_{04.}$	.37 ± .10	.12 ± .13	.33 ± .08
Taught by women			
Number	60	42	102
$r_{04.12}$	−.10 ± .13	.12 ± .15	.07 ± .10
$r_{04.2}$	−.07 ± .13	.14 ± .15	.11 ± .10
$r_{04.}$	.03 ± .13	.27 ± .14	.19 ± .10
Totals			
Number	135	100	235
$r_{04.12}$	.03 ± .09	.08 ± .10	.16 ± .06
$r_{04.2}$	.12 ± .09	.09 ± .10	.18 ± .06
$r_{04.}$	.16 ± .08	.14 ± .10	.22 ± .06

SUMMARY

With respect to personality, the girls made significantly higher scores on the test than did the boys, regardless of the sex of the teacher. The comparison of scores made by boys taught by men and the boys taught by women revealed small, insignificant differences; the differences were in favor of the boys taught by women.

In interest, as indicated by the scores on the interest questionnaire, the groups taught by men and women were similar. However, the differences in scores between boys and girls, whether taught by men or women, favored the girls.

When personality scores were partialled out, and thus held constant, the coefficients of correlation for the relationship between teachers' marks and algebra achievement tended to decrease. The changes were greater in the case of girls

than in the case of boys. The differences were greater in the case of women teachers than in the case of men teachers.

When interest scores were partialled out, and thus held constant, the coefficients of correlation for the relationship between teachers' marks and algebra achievement tended to remain constant.

When teachers' marks were compared with scores on the California Test of Personality with intelligence and algebra achievement partialled out, the resulting coefficients were all positive. The size of the coefficient indicated that the personality scores of girls are more significant than are the scores made by boys in the assigning of marks by teachers of beginning algebra. Women teachers were more influenced by personality factors than were the men teachers.

The factor of interest, since the magnitude of the coefficients was small, does not seem to play an important part in the assignment of marks by teachers of beginning algebra. The direction of the correlation, however, indicated that interest may affect the marks assigned either directly or inversely, provided the teacher is a woman.

CONCLUSIONS

1. To a lesser degree than intelligence (1), personality, as revealed by the scores made on the test, seemed to be a factor in the assignment of teachers' marks. Interest, when it was partialled out, did not appreciably increase the coefficient of correlation between teachers' marks and algebra achievement.

2. When algebra achievement and intelligence were held constant, interest contributed less to the assigned marks than did personality.

3. As for sex differences, the data indicated that girls had the advantage over boys when the effect of non-intellectual factors upon teachers' marks was investigated. In the case of personality and interest, the magnitude of the partial r was in favor of the girls. Interest showed a higher correlation with the marks assigned by men than with the marks assigned by women.

4. It must be concluded in light of the data in the present investigation that the sex of the teacher was not so important in the investigation of marks as was the sex of the student.

5. It must be concluded that marks assigned by teachers of beginning algebra reflect more than achievement. From the evidence at hand, marks in beginning algebra reflect achievement, but they also give evidence of the effect of the intelligence, the personality, and the interest of the student.

RECOMMENDATIONS FOR FUTURE STUDIES

The present investigation could not account for all of the factors that affected the grading or marking situation. In view of the data upon which the conclusions of the present investigation were drawn, further investigation should be directed toward finding answers to the following questions:

1. What are the effects of socio-economic status and age of the student on the assignment of marks by teachers of beginning algebra?

2. Are the factors mentioned above important in the grading situation when investigated in light of sex differences of student and teacher?

3. Of what significance are non-intellectual factors when teachers assign marks?

BIBLIOGRAPHY

1. CARTER, ROBERT S., "How Invalid are Marks Assigned by Teachers," *Journal of Educational Psychology*. In press, accepted September 26, 1950.
2. LENTZ, T. F., "Sex Differences in School Marks with Achievement Test Scores Constant." *School and Society*, 1929, *29*, 65–68.
3. MORTON, R. L., "The Influence of Pupil Conduct on Teachers' Marks." *Educational Research Bulletin*, 1932, *11*, 57–60.
4. RINSLAND, H. D., *Constructing Tests and Grading*. New York: Prentice-Hall, 1937, 2.–11

REDUCTION OF TYPING ERRORS THROUGH POST-HYPNOTIC SUGGESTION[1]

ROBERT SCRIVEN CARTER[2] AND ELIZABETH ANN ORMOND[3]

INTRODUCTION

That performance in various tasks may be improved by suggestion has already been demonstrated. Carmichael, Hogan, and Walter (2) were able through suggestion to improve scores made by college students on a task involving the reproduction of drawings. Fernberger (4) improved the scores of students involved in judging facial expressions, through the use of suggestion.

Hypnosis is best described as a state in which the individual is dreamy, relaxed, and highly suggestible. The fact that suggestion is the key to hypnotism is very apparent when the subject is in a deep trance. Anything, within reason and moral bounds, which the operator suggests that the subject do, will be carried out. It almost seems as if the subject anticipates what he will be required to do, with only the least mention by the operator. He is very cooperative in what is demanded of him. Connected with this is the fact that only the operator can make suggestions to the subject—others in the room may talk to him and tell him to do certain things, but he will completely ignore them, or at least seem to. Estabrooks (3) cites an example of a subject who was told to look for a handkerchief; other people in the room offered him suggestions which were ignored, but when one whispered to another the location of the object, the subject soon looked there. It seems that the subject will pick up cues, although not consciously seeming to hear them. Hypnosis offers a most convncing demonstration of the reality of "subliminal" mental processes. The phenomena of post-hypnotic suggestion provide a dramatic illustration of the influence persisting suggestions may have upon a person's behavior. Post-hypnotic suggestion is an illustration of unconscious motivation. In post-hypnotic suggestion the subject is hypnotized and told that when he wakes up he will remember nothing of what has happened. He is then told that, upon waking, he will perform a certain act. After he is awake, the subject then feels a compulsion to carry out the act suggested, even though he does not know why.

THE PROBLEM

The present problem is designed to test the possibility of reducing errors in typewriting through the use of positive post-hypnotic suggestion.

[1] Submitted in October 1951.

[2] Associate Professor of Psychology, Denison University.

[3] Class of 1951, Denison University.

MATERIALS

Two similar pieces of typing copy were equated as to difficulty of words, length of copy, length of sentences, and subject matter. Subjects were allowed to use the typewriter of their choice, the only stipulation being that the same machine be used for both testing sessions. Timing devices which recorded the time to the nearest one-tenth of a second were used. Subjects consisted of Denison University senior girls. All were selected on the basis of their willingness to give an affirmative answer to the question, "Are you willing to participate in a psychological experiment involving hypnosis?" No further information was given the subjects at the time of selection.

TABLE I

Differences and Critical Ratio between Scores Made on Original Typing Test and Scores Made on Typing Test Following Post-Hypnotic Suggestion

SUBJECT	ORIGINAL TEST		POST-TEST		DIFFERENCE
	Time	Errors	Time	Errors	$E_p - E_o$
1	6.5′	7	6.5′	1	6
2	8.0′	10	7.0′	8	2
3	6.0′	10	6.0′	5	5
4	6.5′	27	6.5′	13	14
5	9.0′	12	9.0′	5	7
6	9.0′	17	9.0′	7	10
Mean		13.8		6.5	

Mean Difference	7.3
Standard Deviation	3.82
Standard Error of the Mean	1.71
Critical Ratio	4.27

PROCEDURE

Each subject was asked to type Copy I before being hypnotized, and the copy was then graded for errors and the time recorded to the nearest one-tenth of a second. Each subject was told that they would be timed while typing, and that errors would be marked, but they were asked to type at normal speed and not to worry about the errors they made nor to make any effort to correct the errors.

After a short rest period, each subject was hypnotized. During the hypnotic trance, each subject was given the following suggestion: "When you wake up, and you won't awaken until I tell you to, I will ask you to type for me again. You will type without errors, making a page of perfect copy. You will type just as rapidly as before, just as rapidly, but you will type better and more precisely than you have ever typed before." The suggestion was repeated several times.

After being awakened from the hypnotic trance, each subject was allowed a

short rest period before proceeding. Next, each subject was asked to type Copy II, using the same typewriter as she had used previously. The time was recorded and the copy graded for errors.

RESULTS

The results for each subject, including time and errors for each set of copy are given in Table I. In each instance the subject typed at least as fast on Copy II as she had done on Copy I. Only one subject (S-2) typed faster than she had done the first time. In every instance, each subject made fewer errors on Copy II.

On Copy I, the mean was found to be 13.8 errors. On Copy II, the mean was found to be 6.5 errors. The standard deviation around the mean difference was found to be 3.82. The standard error of the mean difference was 1.71. Since the difference in means was 7.3, the critical ratio was found to be 4.27. It is thus apparent that differences this large could not have occurred by chance except in less than one case out of a hundred. It is, therefore, clearly shown that differences this large are statistically significant.

SUMMARY

The purpose of the study was to determine the effect of post hypnotic suggestion on the reduction of typing errors. Each subject was first asked to type Copy I; time and errors were carefully recorded. Then the subjects were hypnotized, and while in a deep trance, were given the positive suggestion that upon being asked to type again, they would type just as fast as before, but without errors. Upon awakening, each subject was asked to type Copy II, and time and errors were again recorded. The difference in mean performance was then treated statistically to determine its significance.

CONCLUSIONS

1. The mean difference in typing errors was 7.3, with a critical ratio of 4.27. This is significant at the one percent level of confidence; i.e., in only one out of one hundred cases would differences this large have occurred by chance.

2. The evidence indicates that improvement in motor tasks such as typing can be accomplished through the use of post-hypnotic suggestion.

3. It would seem evident that positive suggestion improves motivation as shown through improved performance.

REFERENCES

1. Bordeaux and Lecron, *Hypnotism Today*, New York: Gruen & Stratton, 1947, pp. 16–27.
2. Carmichael, L., "An Experimental Study of the Effect of Language on the Reproduction of Visually Perceived Form": *Journal of Experimental Psychology*, 1932, *15*, 73–86.
3. Estabrooks, G. H., *Hypnotism*. New York: E. P. Dutton & Co., Inc., 1943. pp. 7–82.
4. Fernberger, S. W., "A Preliminary Study of the Range of Visual Apprehension": *American Journal of Psychology*. 1921, *32*, 121–133.
5. Hull, C. L., *Hypnosis and Suggestibility*. New York: D. Appleton-Century Company, Inc., 1933, pp. ix–x, and pp. 3–104.

THE DENISON SCIENTIFIC ASSOCIATION

A Report

During the academic year 1950–1951 the program of the Denison Scientific Association was planned and directed by the President, Dr. Harry V. Truman. The Secretary, Miss Dorothy Carpenter, has reported the following facts concerning the meetings held. Except as indicated these were held on the basis of public invitation. The average attendance at the open meetings, exclusive of that at the Herrick Memorial lecture on March 27, 1951, was about 33 persons. The average attendance at the closed business sessions, for members only, was 18. These closed sessions were held on the following dates; October 10, 1950, and February 13, April 17, May 1, and May 14, 1951. The lectures at the open meetings were as follows.

October 24, 1950

SOME RECENT DEVELOPMENTS IN ANTIBIOTICS. By Dr. Harry V. Truman, Assistant Professor of Biological Sciences.

November 14, 1950

INDIAN CULTURE TRAITS AND COMPLEXES. By Irving E. Mitchell, Professor of Sociology.

December 12, 1950

NON-INTELLECTUAL FACTORS INVOLVED IN TEACHERS' MARKS. By Dr. Robert S. Carter, Associate Professor of Psychology.

January 9, 1951

SCIENCE AND WORLD AFFAIRS. By Dr. Conrad E. Ronneberg, Professor of Chemistry.

February 27, 1951

BAROQUE INFLUENCE ON TONAL DESIGN OF THE MODERN AMERICAN ORGAN. By Brayton Stark, Associate Professor of Music.

March 13, 1951

SONIC AND ULTRASONIC EFFECTS ON LEARNING. By Dr. Gary C. V. Gawain, Assistant Professor of Psychology.

March 27, 1951

THE BIRTH AND DEATH OF PLANETS. By Dr. Freeman D. Miller, Associate Professor of Astronomy, The University of Michigan.

This was the annual *Clarence Luther Herrick Memorial Science Lecture*, presented to a large audience in Swasey Chapel.

April 10, 1951

SOME CHEMICAL ANALYSIS PROBLEMS IN BIOCHEMISTRY. By Dr. W. Alfred Everhart, Associate Professor of Chemistry.

April 24, 1951

SENIOR HONORS PROJECTS, a series of reports by Denison Seniors.

A NUTRITIONAL STUDY OF FRESH WATER FISH IN LICKING COUNTY. By Herron Mercer.

QUANTUM MECHANICS WITH APPLICATIONS TO THE MOTION OF ELECTRONS IN A PERTURBED PERIODIC LATTICE. By Bruce Johnson.

THEORY AND APPLICATIONS OF REGRESSION AND CORRELATION ANALYSIS. By Mary Langan.

PROPERTIES OF TRIFLUOROACETIC ACID. By David Heiser.

GENERALIZED NORMAL PROBABILITY DENSITY FUNCTION. By William Roach.

PREPARATION AND PHYSICAL PROPERTIES OF TRIFLUOROACETIC ACID. By Laurence Nisbet.

CONDITIONING AUDIOGENIC SEIZURE IN ALBINO RATS. By Kenneth Colman.

May 14, 1951

ANNUAL DINNER MEETING. This was held in the Colwell Dining Hall, followed by the final annual business session in the Shaw Hall recreation rooms. The usual reports were presented, by the secretary-treasurer, by the editor of the *Journal of the Scientific Laboratories*, by the nominating committee. Elections resulted in the appointment of the following list of officers for the academic year 1951–1952.

President	Mr. Samuel C. Wheeler
Vice-President	Miss Dorothy Carpenter
Secretary-Treasurer	Dr. James G. Traynham
Librarian	Dr. Leon E. Smith
Editor and Secretary, *Journal of the Scientific Laboratories*	Dr. W. Alfred Everhart
Committee on Honorary Degrees, 3 years term	Dr. Richard H. Mahard

Plans for a special number (August 1951) of the *Journal of the Scientific Laboratories*, to contain only geological papers written by Denison alumni geologists, and to be dedicated to Emeritus Professor Dr. Frank James Wright, were announced by the Editor.

This report is submitted by W. A. Everhart, Secretary-Editor.

VOLUME 42

SUBJECT AND AUTHOR INDEX

Page

Bates, Thomas F.; Morphology of Layer Lattice Silicates 83

Carter, Robert Scriven; Studies in Validity: The Effect of Personality and Interest on Teachers' Marks 119

Carter, Robert Scriven, and Ormond, Elizabeth Ann; Reduction of Typing Errors Through Post-hypnotic Suggestion 129

Cauchy's Inequality and Some Statistical Inequalities. By Marion Wetzel 107

Chamberlin, Willis A.; History of Theta Chapter of Ohio, Phi Beta Kappa; Appendum V 12

Chazyan Reef Facies Relationships in the Northern Champlain Valley. By Philip Oxley 92

Comparative Study of the Spawning Periods of the Bluegill, Lepomis Macrochirus, the Black Crappie, Pomoxis Nigro-Maculatus (Le Seuer), and the White Crappie, Pomoxis Annularis (Rafinesque), of Buckeye Lake, Ohio, A. By George D. Morgan 112

Denison Scientific Association, Reports Concerning the; By W. Alfred Everhart, Secretary-Editor 17, 132

Everhart, Donald L., and Wright, Robert J.; The Paragenesis of Pitchblende-Bearing Veins 66

Everhart, W. Alfred; In Dedication 64

Reports Concerning the Denison Scientific Association 17, 132

Food, Agriculture and Health. By Charles Glen King 1

History of Theta Chapter of Ohio, Phi Beta Kappa. Appendum V. By Willis A. Chamberlin 12

In Dedication (To Dr. Frank James Wright). By W. Alfred Everhart 64

King, Charles Glen; Food, Agriculture and Health 1

Levin, Ezra, Silbernagel, Wynne, and Nichols, Fred A.; Unidentified Factors in Wheat Germ Oil Influencing Reproduction (A Preliminary Report) 6

Life History of the Bluegill Sunfish, Lepomis Macrochirus, of Buckeye Lake, Ohio, The. By George D. Morgan 21

Morgan, George D.; The Life History of the Bluegill Sunfish, Lepomis Macrochirus, of Buckeye Lake, Ohio 21

A Comparative Study of the Spawning Period of the Bluegill, Lepomis Macrochirus, the Black Crappie, Pomoxis Nigro-Maculatus (Le Seuer), and the White Crappie, Pomoxis Annularis (Rafinesque), of Buckeye Lake, Ohio 112

Morphology of Layer Lattice Silicates. By Thomas F. Bates 83

Nichols, Fred A., Levin, Ezra, and Silbernagel, Wynne; Unidentified Factors in Wheat Germ Oil Influencing Reproduction (A Preliminary Report) 6

Ormond, Elizabeth, and Carter, Robert Scriven; Reproduction of Typing Errors Through Post-hypnotic Suggestion 129

Oxley, Philip; Chazyan Reef Facies Relationships in the Northern Champlain Valley 92

Paragenesis of Pitchblende-Bearing Veins, The. By Donald L. Everhart and Robert J. Wright 66

Paragenesis of a Uranium-Bearing Vein at Caribou, Colorado. By Harold D. Wright 75

Reaction of 2-Methyldihydrobenzofuran with n-Butyllithium, The. By James G. Traynham 60

Reduction of Typing Errors Through Post-hypnotic Suggestion. By Robert Scriven Carter and Elizabeth Ann Ormond..... 129
Silbernagel, Wynne, Levin, Ezra, and Nichols, Fred A.; Unidentified Factors in Wheat Germ Oil Influencing Reproduction (A Preliminary Report)..... 6
Studies in Validity: The Effect of Personality and Interest on Teachers' Marks. By Robert Scriven Carter..... 119
Traynham, James G.; The Reaction of 2-Methyldihydrobenzofuran with n-Butyllithium..... 60
Unidentified Factors in Wheat Germ Oil Influencing Reproduction (A Preliminary Report). By Ezra Levin, Wynne Silbernagel, and Fred A. Nichols..... 6
Wetzel, Marion; Cauchy's Inequality and Some Statistical Inequalities..... 107
Wright, Frank James; Professor *Emeritus* of Geology, Denison University.....64, 65
Wright, Harold D.; Paragenesis of a Uranium-Bearing Vein at Caribou, Colarado..... 75
Wright, Robert J., and Everhart, Donald L.; The Paragenesis of Pitchblende-Bearing Veins..... 66

Article 2, pp. 143–250; December, 1931.....$1.50
The Older Appalachians of the South; Frank J. Wright. 108 pp., 38 plates.

VOLUME 27

Article 1, pp. 1–46; June, 1932.....$1.50
The Geomorphic Development of Central Ohio (Part I); Henry S. Sharp. 46 pp., 1 fig., 6 plates.
Article 2, pp. 47–136; December, 1932.....$1.50
Black River and Other Cephalopods from Minnesota, Wisconsin, Michigan, and Ontario (Part I); Aug. F. Foerste. 90 pp., 31 plates.

VOLUME 28

Articles 1–3, pp. 1–154; April, 1933.....$1.50
Black River and Other Cephalopods from Minnesota, Wisconsin, Michigan, and Ontario (Part II); Aug. F. Foerste. 146 pp.; for plates *cf.* This Journal, Vol. 27, Art. 2 (December, 1932).
A Study of the Change in Mass of the Anode of the Aluminum-Lead Cell; Charles E. Welling. 5 pp.
Balancing Chemical Equations—The Contribution of Otis Coe Johnson (1880); W. C. Ebaugh. 4 pp., 1 plate.
Article 4, pp. 155–248; October, 1933.....$1.00
The Ordos Desert of Inner Mongolia; George B. Cressey. 94 pp., 32 figs., 1 plate.

VOLUME 29

Article 1, pp. 1–105, April, 1934.....$1.25
The Newer Appalachians of the South (Part I); Frank J. Wright. 105 pp., 28 plates, 3 figs.
Article 2, pp. 107–193, August, 1934.....$1.25
Silurian Cyrtoconic Cephalopods from Ohio, Ontario, and Other Areas; Aug. F. Foerste. 86 pp., 14 plates.
Articles 3–4, pp. 195–238, December, 1934.....$1.00
Evidence of Ice Action in the Teays Valley, West Virginia; Julian J. Petty. 10 pp., 4 figs.
The Earlier History of the BULLETIN OF THE SCIENTIFIC LABORATORIES OF DENISON UNIVERSITY; Aug. F. Foerste. 23 pp.

VOLUME 30

Articles 1–2, pp. 1–118, April, 1935.....$1.00
Big Horn and Related Cephalopods; Aug. F. Foerste. 96 pp., 22 plates.
New Light Sources for Photographic Purposes; W. E. Forsythe. 22 pp., 7 figs.
Articles 3–4, pp. 119–230, August, 1935.....$1.00
Correlation of Silurian Formations in Southwestern Ohio, Southeastern Indiana, Kentucky and Western Tennessee; Aug. F. Foerste. 87 pp.
A Study of the Phenomenon of Wetting Films; C. W. Chamberlain and Kenneth Lyle Warren. 25 pp., 4 plates, 1 fig.
Articles 5–6, pp. 231–303, December, 1935.....$1.00
The Cephalopods of the Maquoketa Shale of Iowa; Aug. F. Foerste. 27 pp., 11 plates.
New Genera of Ozarkian and Canadian Cephalopods E. O. Ulrich and Aug. F. Foerste. 32 pp., 1 plate.

VOLUME 31

Articles 1–2, pp. 1–92, April, 1936.....$1.00
Hierosaurus colei; a new aquatic Dinosaur from the Niobrara Cretaceous of Kansas; M. G. Mehl. 20 pp., 3 plates.
Silurian Cephalopods of the Port Daniel Area on Gaspé Peninsula, in Eastern Canada; Aug. F. Foerste. 72 pp., 23 plates.
Article 3, pp. 93–142, August, 1936.....$1.00
The Newer Appalachians of the South (Part II): South of the New River; Frank J. Wright. 50 pp., 6 figs., 32 plates.
Articles 4–6, pp. 143–259, December, 1936.....$1.00
A Study of the Vestigial Air Bladder in the Darter (*Catonotis flabellaris rafinesque*); George David Morgan. 16 pp., 10 plates.
We Must Shape our New World (Commencement Address); Arthur Holly Compton. 11 pp.
Later History of the JOURNAL OF THE SCIENTIFIC LABORATORIES OF DENISON UNIVERSITY; Kirtley F. Mather. 25 pp.
Report of the Permanent Secretary of the DENISON SCIENTIFIC ASSOCIATION. 52 pp.

VOLUME 32

Articles 1–2, pp. 1–131, April, 1937.....$1.00
History of *Theta* Chapter of Ohio, Phi Beta Kappa (1911–1936); Willis A. Chamberlin. 69 pp., 2 figs.
The Tungsten Filament Incandescent Lamp; W. E. Forsythe and E. Q. Adams. 72 pp., 10 figs.
Articles 3–7, pp. 133–207, August, 1937.....$1.00
Science and the College (Commemoration Address); Carey Croneis. 12 pp.
Our Endowment (Commemoration Address); C. Judson Herrick. 9 pp.
Science—Man's Liberator (Commemoration Address); William E. Wickenden. 10 pp.
The Application of Physics to Modern Hydrographic Surveying; (Commemoration Address); Herbert Grove Dorsey. 22 pp., 10 plates.
An Annoted Check-list of Birds Recorded at Granville, Licking County, Ohio; Ward M. Klepfer and William J. Taylor. 21 pp., 1 plate.
Article 8, pp. 209–337, December, 1937.....$1.00
Upper Carboniferous Crinoids from the Morrow Subseries of Arkansas, Oklahoma and Texas; Raymond C. Moore and Frederick N. Plummer. 106 pp., 37 figs. 5 plates.
Report of the Permanent Secretary of the DENISON SCIENTIFIC ASSOCIATION. 10 pp.

VOLUME 33

Article 1, pp. 1–60, April, 1938.....$1.00
The Telescopic Alidade and the Plane Table as used in Topographic and Geologic Surveys; Kirtley F. Mather and Bradford Washburn. 60 pp., 19 figs.
Articles 2–3, pp. 61–155, August, 1938.....$1.00
Chemistry and the Modern Meat Packing Industry; Minard Patrick. 48 pp., 3 figs.
Certain Nuclear Masses in the Macaque Medulla Oblongata—Preliminary Report; Frederick David Goudie. 47 pp., 8 figs.
Articles 4–7, pp. 157–369, December, 1938.....$1.50
The Use of Fragmentary Crinoidal Remains in Stratigraphic Paleontology; Raymond C. Moore. 86 pp., 14 figs., 4 plates.
New Ostracodes from the Golconda Formation; Carey Croneis and Arthur S. Gale, Jr. 46 pp., 2 plates.
New Ostracodes from the Kinkaid Formation; Carey Croneis and Franklin A. Thurman. 34 pp., 2 plates.
New Ostracodes from the Clore Formation, Carey Croneis and Harold J. Funkhouser. 29 pp., 2 plates.
Report of the Permanent Secretary of the DENISON SCIENTIFIC ASSOCIATION. 8 pp.

VOLUME 34

Articles 1–3, pp. 1–63, April, 1939.....$1.00
Some Factors Affecting the Operation of Incandescent Lamps; W. E. Forsythe, E. Q. Adams, and P. D. Cargill. 27 pp., 7 figs.
Taxonomy of Chester Ostracodes; Carey Croneis. 4 pp.
New Ostracodes from the Renault Formation; Carey Croneis and Ralph L. Gutke. 31 pp., 2 plates.
Articles 4–5, pp. 65–169, August, 1939.....$1.00
New Ostracodes from the Menard Formation; Carey Croneis and Hubert M. Bristol. 38 pp., 2 plates.
Pioneering in Yeneseiland. A transect across Siberia from Mongolia to the Arctic; George B. Cressey. 67 pp., 51 figs.
Article 6, pp. 171–294, December, 1939.....$1.00
New Crinoids from Upper Pennsylvanian and Lower Permian Rocks of Oklahoma, Kansas, and Nebraska; Raymond C. Moore. 109 pp., 39 figs., 5 plates.
Report of the Permanent Secretary of the DENISON SCIENTIFIC ASSOCIATION. 8 pp.

VOLUME 35

Articles 1–2, pp. 1–54, April, 1940.....$1.00
The Relative Efficiency of Single Versus Multiple Exposures in the Rapid Memorization of Visual Form; L. C. Steckle. 31 pp., 7 figs.
New Genera of Pennsylvanian Crinoids from Kansas, Oklahoma and Texas; Raymond C. Moore. 23 pp., 9 figs., 1 plate.
Article 3, pp. 55–137, August, 1940.....$1.00
Relationships of the Family Allagecrinidae, with Description of New Species from Pennsylvanian Rocks of Oklahoma and Missouri; Raymond C. Moore. 83 pp., 14 figs., 2 plates.
Articles 4–8, pp. 139–218, December, 1940.....$1.00
Gas Amplification of Photo-electric Currents for High Values of *E/P*; Neil Edward Handel. 28 pp., 15 figs., 1 plate.
Caney Conodonts of Upper Mississippian Age; E. B. Branson and M. G. Mehl. 12 pp., 1 plate.
Conodonts from the Keokuk Formation; E. B. Branson and M. G. Mehl. 10 pp., 1 plate.
A Record of Typical American Conodont Genera in Various Parts of Europe; E. B. Branson and M. G. Mehl. 6 pp., 1 plate.
The Recognition and Interpretation of Mixed Conodont Faunas; E. B. Branson and M. G. Mehl. 15 pp.
Report of the Permanent Secretary of the DENISON SCIENTIFIC ASSOCIATION. 8 pp.

VOLUME 36

Articles 1–3, pp. 1–66, April, 1941.....$1.00
Tegminal Structure of the Pennsylvanian-Permian Crinoid *Delocrinus*; Raymond C. Moore and Harrell L. Strimple. 12 pp., 1 plate.
Fluorescence and Fluorescent Lamps; W. E. Forsythe, B. T. Barnes and E. Q. Adams. 34 pp., 17 figs.

Dakotasuchus Kingi, A Crocodile from the Dakota of Kansas; M. G. Mehl. 19 pp., 3 figs., 2 plates.

Articles 4–5, pp. 67–133, August, 1941 ..... $1.00
What Students Want in an Instructor; L. C. Steckle. 4 pp.
Chemistry and Modern Laundry Practice; Earl R. Haynes. 63 pp., 3 figs.

Articles 6–8, pp. 135–174, December, 1941 ..... $1.00
Illinoian Glaciation in Killbuck Valley South of Millersburg, Ohio; George D. Hubbard. 11 pp., 1 fig.
Biological Sociology; Alfred Edwards Emerson. 10 pp.
The Life Science Building at Denison University; Arthur Ward Lindsey. 4 pp., 1 fig.
Report of the Permanent Secretary of the DENISON SCIENTIFIC ASSOCIATION. 15 pp

VOLUME 37

Articles 1–2, pp. 1–66, April, 1942 ..... $1.00
A Preliminary Revision of Hesperia; Arthur Ward Lindsey. 50 pp., 6 plates.
The Growth of the Tourist Court in the United States, and its Relationship to the Urban Development of Albuquerque, New Mexico; Franklin T. McCann. 1f pp., 5 plates.

Articles 3–7, pp. 67–132, August, 1942 ..... $1.00
Megaliocrinus, A new Camerate Crinoid Genus from the Morrow Series of Northeastern Oklahoma; Raymond C. Moore and Lowell R. Laudon. 10 pp., 5 figs.
Metacatillocrinus, A new Inadunate Crinoid Genus from Pennsylvanian Rocks of Oklahoma; Raymond C. Moore and Harrell L. Strimple; 8 pp., 6 figs.
Blastoids from Middle Pennsylvanian Rocks of Oklahoma; Raymond C. Moore and Harrell L. Strimple; 7 pp., 1 fig.
A New Species of Synbathocrinus from Mississippian Rocks of Texas, with Description of Ontogeny; Raymond C. Moore and John D. Ewers. 15 pp., 28 figs.
Mercury Vapor Lamps; W. E. Forsythe, E. Q. Adams and B. T. Barnes. 26 pp., 20 figs.

Articles 8-9, pp 133-163, December, 1942 ..... $1.00
Geography in a World at War; C. Langdon White. 7 p.
The Meaning of Science in Human Affairs; C Judson Herrick. 13 pp.
The Denison University Research Foundation. 1 p.
Report of the Permanent Secretary of the DENISON SCIENTIFIC ASSOCIATION. 7 pp.

VOLUME 38

Articles 1–2, pp. 1–39, April, 1943 ..... $0.75
Establishing and Maintaining a Color Temperature Scale; W. E. Forsythe and E. Q. Adams. 31 pp., 9 figs.
The Vegetation of Idaho; R. Maurice Myers. 8 pp. 1 fig.

Articles 3–4, pp. 41–76, December, 1943 ..... $0.75
The Cranial Nerves. A Review of Fifty Years; C. Judson Herrick. 12 pp.
Radiometric and Colorimetric Characteristics of the Blackbody between 2800°K and 3800°K; E. Q. Adams and W. E. Forsythe. 17 pp., 1 fig.
Report of the Permanent Secretary of the DENISON SCIENTIFIC ASSOCIATION. 8 pp.

VOLUME 39

Article 1, pp. 1–54, June, 1945 ..... $0.75
The Disappearing-filament Optical Pyrometer Calibration and Use; W. E. Forsythe and E. Q. Adams. 48 pp. and 18 figs.
Report of the Permanent Secretary of the DENISON SCIENTIFIC ASSOCIATION for 1944. 5 pp.

Article 2, pp 55–90, December, 1945 ..... $0.75
Photometry; Field Brightness and Eye Adaptation; W. E. Forsythe and E. O. Adams. 29 pp. and 4 figs.
Report of the Permanent Secretary of the DENISON SCIENTIFIC ASSOCIATION for June to December, 1945. 7 pp.

Articles 3–7, pp. 91–170, June, 1946 ..... $1.00
Dyadic Operator Approach to a Study in Conics, with Some Extension to Higher Dimensions; James Loyd Shawn. 15 pp.
Dyadic Operator as Applied to Lines, Planes and Quadric Surfaces; Laura Lee Cowen. 7 pp.
Spectrograph and its Use in Spectrochemical Analysis; Betty Jane Oestmann. 21 pp., 5 figs.
Synthetic Rubbers; William Farrand Loranger and Robert Garfield Anderson. 22 pp., 2 figs.
Role of Suggestibility in Susceptability to the Size Weight Illusion and the Phenomenon of Autokinetic Streaming; Suzanne Littell. 75 pp., 2 figs.

Articles 8-9, pp. 171-194, December, 1946 ..... $1.00
Existence and Condition of Minimum Deviation of a Prism; Robert E. Seall. 4 pp., 1 fig.
Natural History Collections of Denison University; C. Judson Herrick. 8 pp.
Report of the Permanent Secretary of the DENISON SCIENTIFIC ASSOCIATION, 12 pp.
Subject and Author Index, January, 1944 to December, 1946. 5 pp.

VOLUME 40

Articles 1–3, pp. 1–32, April, 1947 ..... $1.00
In Appreciation. A Report by the Editor; 2 pp., 1 plate
Conodonts from the Fern Glen of Missouri; M. G. Mehl and Leo A. Thomas. 18 pp., 1 plate
Where do we Stand with Cancer? Ralph E. Pickett. 11 pp.

Article 4, pp. 33–72, August, 1947 ..... $1.00
Metric Differential Geometry of Reciprocal Retilinear Congruences; Winthrop W. Dolan. 34 pp.
Program of the Denison Scientific Association. A Report by the Permanent Secretary; 5 pp.

Articles 5–6, pp, 73–115, December, 1947 ..... $1.50
The Autokinetic Test as a Measure of Introversion-Extroversion; Marcia Helen Voth. 14 pp.
A Comparative Study of the Variations of the Postrenal Vena Cava of the Cat and the Rat and a Description of Two New Variations; Norman B. Abell. 28 pp.; 23 plates.

VOLUME 41

Article 1, pp. 1-38; April, 1948 ..... $1.00
The Role of Security-Insecurity Feelings in Liberal and Conservative Attitudes; Martha F. Sturm. 38 pp., including 10 figs., 13 tables.

Articles 2–3, pp. 39–66; December, 1948 ..... $1.25
Observations on the Michigan Flora: A Survey of the St. Ignace Causeway (Mackinac County); Edward G. Voss. 7 pp.; 2 plates.
The Male Frog Pregnancy Test; Carl F. Brandfass, Jr. and Emil J. Massa; 20 pp.; 3 plates.
Report of the Secretary; THE DENISON SCIENTIFIC ASSOCIATION; 1 p.

Articles 4–6, pp. 67–95; April, 1949 ..... $1.00
Determinants Via Mathematical Induction; Forbes B. Wiley. 10 pp.
Observations on the Michigan Flora, II: Some Plants New or Rare in Emmet, Cheboygan and Mackinac Counties, Michigan; Edward G. Voss. 5 pp.
Letters from Germany by a Mid-western College Professor, 1867–1868; Willis A. Chamberlin. 14 pp.

Article 7, pp. 97–127, August, 1949 ..... $1.25
Late Cenozoic Chronology of the Upper Verde Valley, Arizona; Richard H. Mahard. 30 pp., 13 figures, 10 plates.
Report of the Secretary; THE DENISON SCIENTIFIC ASSOCIATION. 1 pp.

VOLUME 42

Articles 1–3, pp. 1–19; April, 1950 ..... $1.00
Food, Agriculture and Health; Charles Glen King. 5 pp.
Unidentified Factors in Wheat Germ Oil Influencing Reproduction (A Preliminary Report); Ezra Levin, Wynne Silbernagel and Fred A. Nichols. 6 pp.
Appendum V. History of Theta Chapter of Ohio, Phi Beta Kappa; Willis A. Chamberlin. 5 pp.
A Report concerning THE DENISON SCIENTIFIC ASSOCIATION; W. A. Everhart. Secretary-Editor. 3 pp.

Articles 4–5, pp. 21–63: April, 1951 ..... $1.25
The Life History of the Bluegill Sunfish, Lepomis Macrochirus of Buckeye Lake, Ohio; George D. Morgan. 37 pp., 2 plates.
The Reaction of 2-Methyldihydrobenzofuran with *n*-Butyllithium; James G. Traynham. 4 pp.

Articles 6–10, pp. 64–106; August, 1951 ..... $1.50
In Dedication; W. A. Everhart. 1p., 1 plate.
The Paragenesis of Pitchblende-Bearing Veins; Donald L. Everhart and Robert J. Wright. 9 pp., 1 plate.
Paragenesis of a Uranium-Bearing Vein at Caribou, Colorado; Harold D. Wright. 8 pp., 6 figures.
Morphology of Layer Lattice Silicates; Thomas F. Bates. 9 pp., 4 figures.
Chazyan Reef Facies Relationships in the Northern Champlain Valley; Philip Oxley. 15 pp., 5 plates, 2 figures.

Articles 11–14, pp. 107–136; December, 1951 ..... $1.25
Cauchy's Inequality and Some Statistical Inequalities; Marion Wetzel. 5 pp.
A Comparative Study of the Spawning Periods of the Bluegill, Lepomis Macrochirus, the Black Crappie, Pomoxis Nigro-Maculatus (Le Seuer), and the White Crappie, Pomoxis Annularis (Rafinesque), of Buckeye Labe, Ohio; George D. Morgan. 7 pp., 4 graphs.
Studies in Validity: The Effect of Personality and Interest on Teachers' Marks; Robert Scriven Carter. 10 pp.
Reduction in Typing Errors Through Post-hypnotic Suggestion; Robert Scriven Carter and Elizabeth Ann Ormond. 3 pp.
A Report Concerning THE DENISON SCIENTIFIC ASSOCIATION; W. A. Everhart, Secretary-Editor. 2 pp.